IN THE MATTER OF
KOREAN PATENT APPLICATION
UNDER SERIAL NO. 3184/1999

I, THE UNDERSIGNED, HEREBY DECLARE :
THAT I AM CONVERSANT WITH BOTH THE KOREAN AND THE ENGLISH LANGUAGES : AND

THAT I AM A COMPETENT TRANSLATOR OF THE APPLICATION PAPERS THE PARTICULARS OF WHICH ARE SET FORTH BELOW :

KOREAN PATENT APPLICATION UNDER SERIAL NO.:	3184/1999
FILED ON :	February 1, 1999
IN THE NAME OF :	LG ELECTRONICS INC.
FOR :	DATA STRUCTURE OF MULTI-LEVEL IMAGE AND METHOD FOR IMAGE CHECKING USING THIS STRUCTURE

IN WITNESS WHEREOF, I SET MY HAND HERETO

THIS 9TH DAY OF SEPTEMBER, 2005

BY _____

Ye Jin KIM

[Translation]

PATENT APPLICATION

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The Patent Office

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Title of the Invention : DATA STRUCTURE OF MULTI-LEVEL IMAGE AND METHOD FOR IMAGE CHECKING USING THIS STRUCTURE

Applicant : LG ELECTRONICS INC.
Code No. : 1-1998-000275-8

Attorney : Name : CHOI, Yeong Bok
Code No. : 9-1998-000571-2

Inventor : Name : KIM, Hyeon Jun
Resident Reg. No.: 640904-1117118
Zip code : 463-030
Address : Hanshin-Life 109-302, Bundang-Dong, Bundang Gu, Seongnam, Gyeonggi-Do, Korea
Nationality : Republic of Korea

Name : JUN, Sung Bae
Resident Reg. No.: 711010-1057913
Zip code : 153-034
Address : 804, Siheung 4-Dong, Geumcheon-Gu, Seoul, Korea
Nationality : Republic of Korea

Name : LEE, Jin Soo
Resident Reg. No.: 710502-1080034
Zip code : 138-122
Address : Samik Apt. 101-804, 573, Macheon 2-Dong, Songpa-Gu, Seoul, Korea
Nationality : Republic of Korea

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This application is hereby filed pursuant to Article 42 of the Patent Law and request for examination is filed pursuant to Article 60 of the Patent Law.

/S/ Attorney : CHOI, Yeong Bok

[Fee]

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[Attached document]

1. Abstract, Specification (Drawing) – 1copy

Encls.

[Translation]

ABSTRACT OF THE DISCLOSURE

[Abstract]

The present invention relates to an image search method capable of expressing one color feature related to a spatial color feature of a still image based on a multilevel image grid and searching target images using the expressed multilevel image grid. In the conventional art, since one color feature is expressed based on one image grid level. In this case, the importance of each feature is expressed but an element-based importance of each feature is not adopted. In addition, since the element-based average importance is various based on the characteristic of the reference image or target images, it is impossible to effectively response for a user's contents-based image search. In the present invention, one feature has a multilevel image grid, and each level is formed of cells of hierarchical grids of different levels for thereby obtaining a data structure in which each cell corresponding to the grid is expressed based on a reliability on a region representative color and a similarity of the region representative color, so that it is possible to fast and accurately search images with respect to a user's content-based query based on a cell matching of the same level as two image grids and different levels or a color local matching of the grid match.

[Representative Drawing]

Figure 1

[SPECIFICATION]

[Title of the Invention]

Data structure of multi-level image and method for image checking using this structure

[Brief description of the Drawings]

Fig. 1 shows an embodiment of a multi-level image data structure according to the present invention, which shows a 3-level image data structure;

Fig. 2 shows a match between 3-level image grids in an image detecting method using a multi-level image data structure according to the present invention;

Fig. 3 shows a match between the same levels in the match between the 3-level image grids shown in the embodiment of Fig. 2;

Fig. 4 shows the embodiment of Fig. 2, (a) showing two identical image grid levels, and (b) showing a match between two image grids; and

Fig. 5 shows a match between two different image grid levels in the embodiment of Fig. 2.

[Detailed description of the invention]

[Object of the invention]

[Field of the invention and background art]

The present invention is directed to an image search method using a multilevel image grid by which one color feature related to a spatial color property of a still image is expressed.

In a conventional image search method, features such as color, shape, texture, and the like are expressed in an image grid data structure of one level, and similarity of the features are searched.

At this time, the importance of each feature is different according to the characteristics of an image to be searched. In addition, even with respect to only one feature, the importance thereof is different according to parts of cells existing in its grid.

For instance, in the image search method using a color histogram, which is formed in a n-dimensional structure, a weight value can be determined as a different value for each element forming the n-dimensional structure.

Thus, in the conventional method, the importance between features has been expressed based on the image grid expressed by one level for one image. However. The importance for each element within the independent feature has not been considered. Also, another method for previously calculating the average importance for each element for determination has been used.

The average importance for each element varies by a reference image or a target image. Accordingly, the determining of the average value for elements is not useful in image search.

In addition, since the image grid data structure is formed of only one level, data for the image grid is not accurately searched. As a result, it is impossible to carry out an optimal search for a user's query.

[Technical object of the present invention]

Therefore, in order to solve the above problem, an object of the present invention is to provide a data structure in which one feature has a multilevel image grid, each of which levels is allowed to be formed of cells of a hierarchical structure of different levels, and each cell is expressed by a region representative color and a reliability expressing a similarity with respect to the region representative color value.

Another object of the present invention is to provide an image search method

capable of effectively corresponding to a user's query by cells of the same level of two image grids and different levels or a grid match and a color region match to perform the searching of a color similarity with respect to different multilevel image grids corresponding to reference destination image.

[Construction of the present invention]

To achieve the above objects according to the present invention, there is provided a multilevel image data structure in which a spatial color feature of one image is expressed in a hierarchical image grid structure having at least two or more different levels.

The hierarchical image grid of each level is characterized by hierarchically dividing resolution of cells in proportion to height and width of the corresponding image and thus hierarchically improving the resolution of the cells of each level.

For square image (quad tree structure), the hierarchical level of each image grid is hierarchically divided by uniformly dividing an aspect ratio (height: width), whereas for non-square image (non-quad tree structure), one side of the aspect ratio is uniformly divided, and the other side thereof is hierarchically divided by the unit of the one side.

An image search method using such multilevel image data structure is characterized by which region representative colors with respect to regions between different images divided into multilevel are matched to reliability indicating accuracy of the representative color value, and thus color similarity can be searched according to a user content-based query.

The color similarity between two images having different hierarchical grids may be searched according to difference of similarities for representative color values of two color points having a spatial color feature by matching each cell included in two different

image grids, searched by matching two image grids, performing a multi-cross in accordance with a spatial color feature between the two images, and searching color similarities, and searched by matching each region representative color value for thereby searching the same regions.

Such image search method using the multilevel image data will now be explained with reference to Figs. 1 to 5.

First, one image data structure is expressed in a multilevel image grid structure in which the spatial color feature is divided into hierarchical grids of different levels.

Each image grid is a hierarchical structure of different levels, and the resolution of each level is hierarchically divided. The cell of each grid is assigned with two values which are a region representative color (RRC) and a reliability score (S) related to accuracy of the region representative color.

For a quad tree structure, an aspect ratio of the multilevel image grid is uniformly divided, and for non-quad tree structure, one side is uniformly divided in accordance with an aspect ratio of a width and height of an image, and the other side is uniformly divided by the unit of the one side.

That is, a regular square structure having the same length of horizontal and vertical sides is divided by the same unit with respect to the aspect ratio, and for a rectangular structure having different lengths of horizontal and vertical sides, one side (e.g., a lengthy side) is uniformly divided, and the other side (e.g., a shorter side) is divided by the dividing unit of the one side.

Fig. 1 illustrates an embodiment of a multilevel image grid data structure according to the present invention, which shows a 3-level grid data structure. The 3-level image grid is divided into image grids of top (first) level, second level, and third level.

In the resolution of the 3-level image grid data structure, the top level image grid

is the lowest, the second level image grid is an intermediate level, and the third level image grid has the finest final resolution.

The top level image grid is divided into the image region including a plurality of local cells in proportion to the aspect ratio (M1xN1) of a width M1 and a height N1. Each cell is expressed as a region representative color(RRC) which represents each region, and a reliability score(S) which corresponds to the accuracy of the representative color value.

The second level image grid and the third level image grid are divided into the image regions including a plurality of local cells in accordance with the dividing state, and each cell has a region representative color(RRC) and a reliability score(S).

For example, when the maximum width M and the height N of the top level image grid are 8(=8x8), the maximum width M2 and the height N2 of the second level image grid are 16(=16x16), and the maximum width M3 and the height N3 of the third level image grid are 32(=32x32) of the local cells.

Here, a certain cell Cell(i,j) of the third level image grid is expressed as a region representative color and a reliability score C^3_{ij}, S^3_{ij}.

At this time, the number of divisions of each of the image levels of top level, second level and third level is determined based on an aspect ratio of width and height of the image for accurately expressing the position. Namely, in the case of the lengthy side, the lengthy side is uniformly divided, and the shorter side is divided by the divided unit of the lengthy side.

In another method for generating the grid of the image, to increase processing speed and to consider only approximate positional information, each vertical and horizontal length of the grid may be identically set.

The image search method using the multilevel image grid data structure will be explained.

Different images divided into the multilevel image grids are expressed as a representative region color(RRC) for representing the region and a reliability score (C) for expressing an accuracy of the representative color, and a pair of representative region color and reliability are matched to another one, and a cell similarity is computed in accordance with the user content-based query for thereby performing an image search.

The color similarity between two images which is used as a multilevel image grid is computed by comparing the cells included in an image grid of each level and each image grid, and the region color(RRC) representing each cell.

The color similarity between two cells is computed by matching a region representative color value between the cell $Cell_1$ and Cell $Cell_2$ to the color similarities $Color\_Sim(RRC\_of\_Cell_1, RRC\_of\_Cell_2)$ which represent the similarity.

A first weight value (α) is multiplied by a square of the reliabilities $S\_of\_Cell_1$ and $S\_of\_Cell_2$ for the region representative color RRC of two cells so as to obtain a color reliability W which is then multiplied by the color similarities Color_Sim. Thereafter, the resultant value is summed by the result obtained by multiplying the similarity I with respect to a reliability between two cells and the second weight (β). The summed value is then divided by a normalized value.

Thus, the color similarities $Sim(Cell_1, Cell_2)$ of the cells $Cell_1$ and $Cell_2$ included in the image can be obtained according to the following equation 1.

[Equation 1]

$$Sim(Cell_1, Cell_2) = \frac{\alpha \times W \times Color\_Sim(RRC\_of\_Cell_1, RRC\_of\_Cell_2) + \beta \times I}{\alpha + \beta}$$

In the equation 1, the color reliability W which represents how similar the region

representative color RRC value between the two cells $Cell_1$ and $Cell_2$ is can be indicated according to $= (S\_of\_Cell_1 \times S\_of\_Cell_2)$. The similarity (I) of the reliability which represents how reliable the reliability between two cells is can be indicated according to $I = 1-(S\_of\_Cell_1 - S\_of\_Cell_2)^2$.

The weight values (α) and (β) are multiplied, respectively, by the color reliability W and the similarity I of the reliability. A normalized value is obtained by multiplying the two weight values ($\alpha+\beta$) to each other.

Thus, the color similarity can be searched according to difference of similarities for representative color values of two color points having a spatial color feature by matching each cell included in two different image grids.

Conversely, the similarity of the color feature between two different multilevel image grids can be obtained by matching the same levels to different levels of the multilevel image and searching the similarity for the color feature of the images.

Fig. 2 illustrates an embodiment of the present invention, and shows reliability between grids of two images I_1 and I_2 having a 3-level image.

For two images I_1 and I_2, the reference image I_1 has top level G_1_top, second level G_1_2^{nd}, third level G_1_3^{rd} image grids, and the reference image I_2 has top level G_2_top, second level G_2_2^{nd}, third level G_2_3^{rd} image grids.

The reliability $Sim(G_1,G_2)$ between each grid level included in the two images is searched by crossing between levels, which can be obtained according to an equation 2 as follows.

[Equation 2]

$$
\begin{aligned}
Sim\ (G_1, G_2) = & w_1 \times Sim\_of\_the\_Exact_{G1\_top\_level\_and\_G2\_top\_level} \\
& + w_2 \times Sim\_of\_the\_Exact_{G2\_2nd\_level\_and\_G2\_2nd\_level} \\
& + w_3 \times Sim\_of\_the\_Exact_{G1\_3rd\_level\_and\_G2\_3rd\_level} \\
& + w_4 \times Sim\_of\_the\_Inter_{G1\_top\_level\_and\_G2\_2nd\_level} \\
& + w_5 \times Sim\_of\_the\_Inter_{G1\_top\_level\_and\_G2\_3rd\_level} \\
& + w_6 \times Sim\_of\_the\_Inter_{G2\_2nd\_level\_and\_G2\_top\_level} \\
& + w_7 \times Sim\_of\_the\_Inter_{G1\_2nd\_level\_and\_G2\_3rd\_level} \\
& + w_8 \times Sim\_of\_the\_Inter_{G1\_3rd\_level\_and\_G2\_top\_level} \\
& + w_9 \times Sim\_of\_the\_Inter_{G1\_3rd\_level\_and\_G2\_2nd\_level}
\end{aligned}
$$

Here, w1~w9 denote weight values for representative color similarities. The reliability can be searched by dividing a similarity Sim_of_the_Extract between the same image grid levels for the two images I_1 and I_2, and a similarity Sim_of_the_Inter between different image grid levels thereof.

Then, the similarity Sim_of_the_Extract between the same image grid levels included in the two different images can be searched by matching the two images to each other as shown in Fig. 3.

That is, similarities of two cells corresponding to the same levels of the two different images are summed together, and the similarities of two cells are summed to the summed value by shifting in the horizontal and vertical directions by the difference of the aspect ratio (width: height).

At this time, the number of the matches of two grids is computed by adding 1 to the absolute value of the difference of the aspect ratio of a certain level of two images.

For example, for the two images I_1 and I_2, if the width of the image I_1 is M and its height is N, and the width of the image I_2 is O and its height is P, the total number of matches between two grids is $(|M-O|)+1)x(|N-P|+1)$.

The similarity between two cells corresponding to the same grid levels

Max(M,N)=Max(O,P) is calculated by matching two grids, as shown in Fig. 4, based on different shift amount in accordance with the aspect ratio (width: height) of two grids.

At this time, the similarity Sim_of_the_Exact based on the match between the same levels of two images I_1 and I_2 is obtained based on the following Equation 3.

[Equation 3]

$$Sim\_of\_the\_Exact = Max\ (Similarity\_between\_two\_levels\_given\_cell\_correspondence\ S(i,j))$$
$$Vi, 0 \le i \le |M - O|$$
$$Vj, 0 \le i \le |N - P|$$

$$Similarity\_between\_two\_Grids\_cell\_correspondence\ S(i,j)$$
$$= \frac{\sum_{y=0}^{Min|N-P|-1} \left(\sum_{x=0}^{Min|M-O|-1} Similarity\_of\_corresponding\_two\_cells(x, y, i, j) \right)}{Min(N, P) \times Min(M, O)}$$

When matching the similarity (Sim_of_the_Exact) between the same levels, the $\sum_{y=0}^{Min(|N-P|-1)} \left(\sum_{x=0}^{Min(|M-O|-1)} Sim\_of\_corres\_two\_cells \right)$ represents a sum of the matching with respect to the width and height of two corresponding cells. $\sum_{j=0}^{|N-P|} \sum_{i=0}^{M-O|}$ denotes the sum for the shift amount.

The similarity Sim_of_corresponding_two_cells between two cells is obtained from the following Equation 4 by adapting Equations (1)(2)(3)(4) based on the aspect ratios (M,N), (O,P).

[Equation 4]

$$Sim(cell^{G1}(x+i, y+j), cell^{G2}(x, y)), \quad if\ (Min(N,P) = P) \cap (Min(M,O) = O)$$

$$Sim(cell^{G1}(x+i, y), cell^{G2}(x, y+j)), \quad if\ (Min(N,P) = N) \cap (Min(M,O) = O)$$

$$Sim(cell^{G1}(x, y+i), cell^{G2}(x+i, y)), \quad if\,(Min(N,P) = P) \cap (Min(M,O) = M)$$

$$Sim(cell^{G1}(x, y), cell^{G2}(x+i, y+j)), \quad if\,(Min(N,P) = N) \cap (Min(M,O) = M)$$

Here, the equation (1) is applied when the aspect ratio (P:O) of the second grid G_2 has the minimum value (min=P:O) with respect to the aspect ratio N:M of the first grid G_1. Equation (2) is applied when the horizontal length N of the first grid G_1 is short (min) and the vertical length O of the second grid G_2 is short. In addition, Equation (3) is applied when the vertical length P of the second grid G_2 is short (min), and the horizontal length M of the first grid G_1 is short, and Equation (4) is applied when the aspect ratio N of the first grid G_1 is longer than the aspect ratio P of the second grid G_2.

The shift amount (i,j) with respect to the length difference (|M-O|,|N-P|) between the length of the first grid G_1 and that of the second grid G_2 is added to the cell coordinate (x, y), and each of start point (i,i,x,y) becomes 0.

The similarity Sim_of_the_Inter between different grid levels (Max(M,N) $\neq$ Max(O,P) is calculated by matching two different image grid levels. The operation is performed similarly as the search of the grid level similarity Sim_of_the_Exact.

In addition, the number of the matches of the image grids between different image grid levels is obtained based on (|M-O|+1)x(|N-P|+1) by considering the aspect ratio (M,N)(O,P).

The color region matching operation is performed for searching the region in which the representative color values are similar between the multilevel image grids. The search is performed based on a method for searching the color similarity from a translation position and a relative position between the grid level (Exact scale matching) of the same size, and a method for searching the color similarity from a translation

position and the relative position between the grid levels (Inter-scale matching) of different sizes.

The color region matching operation between the image grid levels(Exact scale matching) of the same size is performed based on a method for searching a color region of the same levels from a target image. The position is matched with the relative position based on the same image grid level of the target image, and then the similarity of the color region is computed, and the position is matched with a translation position at the same level of the target image for thereby computing a similarity of the color region.

The color region matching operation between the different image grid levels(Inter-scale matching) is performed based on a method for searching the different level color regions among different image grid levels of the target image.

In the color region matching method of between different image grid levels, the similarity of the color region is computed by matching the position with the same position among the different image grid levels of the target image, and the similarity of the color region is computed by matching the position with the translation position at another level of the target image.

[Effect of the invention]

As mentioned above, in the present invention, one image grid data structure is divided into multilevel grid data structures. Therefore, it is possible to effectively response with respect to a subjective query by a user when searching a content-based image using the divided multilevel grid structures. In addition, an image search speed is fast and accurate under a certain condition.

What is claimed is:

1. A multilevel image data structure in which a spatial color feature of one image expressed in a still image is expressed in an image grid having at least more than two different hierarchical levels.

2. The structure of claim 1, wherein the hierarchical image grid of each level is characterized by hierarchically dividing resolution of cells in proportion to height and width of the corresponding image grid, and each cell is expressed based on a reliability on a region representative color and a similarity of the region representative color.

3. The structure of claim 1, wherein the hierarchical level of each image grid is hierarchically divided by uniformly dividing an aspect ratio when an original image has a quad tree structure.

4. The structure of claim 1, wherein in the hierarchical level of each level, for non-quad tree structure, one side of the aspect ratio is uniformly divided, and the other side thereof is hierarchically divided by the dividing unit of the one side.

5. An image search method using a multilevel image data structure capable of searching images according to a user's content-based query by matching a spatial color feature of a reference image divided into different hierarchical image grid levels and a color similarity of a target image.

6. The method of claim 5, wherein the color similarity between two images

having different hierarchical grid levels is searched according to difference of similarities for representative color values of two color points having a spatial color feature by matching each cell included in two different image grids.

7. The method of claim 5, wherein the color similarity between the two images having the different hierarchical grids is obtained by matching two image grids, performing a multi-cross in accordance with a spatial color feature between the two images, and searching color similarities.

8. The method of claim 5, wherein the color similarity between the two images having the different hierarchical grids is obtained by matching each region representative color value for thereby searching the same regions.

9. The method of claim 5 or 7, wherein the color similarity between cells included in images having different hierarchical levels is obtained by multiplying a square of the reliability representing a similarity of the region representative colors between two cells which are target images by a weight, adding another weight to the similarity of the reliability representing the similarity of reliability between two cells, and normalizing the color similarity.

10. The method of claim 5 or 7, wherein the color similarity between multilevel images is obtained based on the total value summed as the values are shifted in a horizontal and vertical direction based on the shifting amount by the difference of the aspect ratio corresponding to two cells when the same levels of target image grids are matched, and a similarity thereof is searched.

11. The method of claim 5 or 7, wherein a color similarity between the multilevel images is obtained based on a value summed as the values are shifted in a horizontal and vertical direction by the difference of the aspect ratio corresponding to two cells included in each level in the case that different levels of two images are matched, and then a similarity is searched.

12. The method of claim 5, wherein a cell similarity between image grids having a multilevel is used for searching the same position and different position between the same levels between the images in the case that the search is performed by matching the color region.

13. The method of claim 5, wherein a color region matching operation between two image grids having a multilevel is directed to searching at the same position of different levels and at different position when searching the color similarity between different levels.